ON DIPLOGRAPTIDÆ, LAPWORTH.[1]

In the fall of 1888, H. Munthe brought from Bornholm a piece of Baltic sea limestone[2] [Ostseekalk] with graptolites, which he kindly gave me, as I was at work on the Silurian region of the Bothnian sea. From this piece, half the size of one's fist, I have obtained, by the aid of muriatic acid and vinegar, several hundred pieces of a *Diplograptus*. As this compact limestone is excellently qualified to preserve the very finest details, the fragments, which consist mainly of proximal-ends and sciculæ, furnish excellent material for the examination of the inner organization of this particular *Diplograptus*.

These remains are of a half-carbonized, chitinous substance, and after separation were dark brown and almost opaque, therefore I treated them with Schulze's maceration medium by which their color was changed to light brown or yellow. After careful washing with water, they were further treated with alcohol and oil of cloves, and were then preserved in the ordinary way in Canada balsam.

According to the present acceptation, as recorded in general hand-books of paleontology,[3] and in the main the same as that given by Lapworth[4] as early as 1873, the family *Diplograptidæ*, Lapw., is characterized as follows: Hydrozoma, consisting of two branches united dorsally, between which the scicula is imbedded, its broadest portion forming the proximal end of the hydrozoma.

[1] Extract from Bulletin of the Geological Institute of Upsala, Vol. I, No. 2, 1893. Translated from the German by CHARLES SCHUCHERT.

[2] C. WIMAN: Ueber das Silurgebiet des Bottnischen Meeres, I, p. 73, Bull. Geol. Instit., of Upsala, Vol. I, No. 1, 1893.

[3] K. A. ZITTEL: Handbuch der Palæontologie, Abtheilung I, Band I, 1876-1880. H. A. NICHOLSON and R. LYDEKKER: A Manual of Palæontology for the use of students, Part I, Third Edition, 1889.

[4] Notes on British Graptolites and their Allies, I.—On an improved Classification of the *Rhabdopora*, Parts I and II, Geol. Mag., Vol. X, pp. 500, 555, 1873.

Since in fact the graptolites are generally compressed and altered into a metallic sulphide, or are otherwise poorly preserved, and as this was also largely the case with the material examined by Lapworth, the genus *Diplograptus* was referred to the *Diprionidæ*, mainly by a comparison with other forms, particularly *Didymograptus* and *Dicranograptus*.

In 1876, Lapworth[1] described two species of a new genus, *Dimorphograptus*, and, because of these, doubted the existence of any diprionidian forms. The proper view, he believed, was that the scicula in all graptolites develops but one bud. This view (an opinion founded on fact) that a monoprionidian scicula which at first gives off a monograptus-like hydrosoma could really give origin to a complete diplograptus-like distal end, has in later literature never been considered, but the older idea has been persistently retained to the present time.

The Scicula. In the present material, this is represented by 168 specimens, and of these 85 are separate. The form of the scicula is given in Pl. II., fig. 1-5 and 7-9. It is divisible into two essentially different parts, the distal one having a very thin and transparent wall, while the proximal is thicker and less transparent. Along the wall of the distal part are longitudinal thickenings or lines which branch and anastomose basally, and are lost near the boundary with the proximal portion. They unite, however, in the point of the scicula, and form the distal portion of the virgula to which I will again refer. Between the two parts of the scicula there is no septum.

In the proximal part of the scicula can be seen closely arranged diagonal lines, which I regard as growth lines. These have the same appearance as the often described thecal lines, differing only in the fact, that at a certain distance from the virgula, they gradually bend downward to join it at a sharp angle. In the very oldest part of the proximal portion of the scicula, the lines round regularly (Pl. II., fig. 1), since the virgula, when these were forming, was not yet present. Very soon, however, they begin to exhibit a slight downward bending, and this increases

[1] On Scottish *Monograptidæ*. Geol. Mag., Decade II, Vol. III, p. 544, 1876.

line for line until the virgula begins to show, and practically absorbs the lines. The angle at which the lines and the virgula unite diminishes with age. The mature scicula is provided with three spines at its aperture, one of which is the cylindrical virgula. The other two are flat, and should probably be termed lobes. They have that appearance, as shown in figure 5, and are situated opposite the virgula on each side of a shallow emargination of the aperture, joined by a slight swelling of the border of the indentation.

The form and completion of the aperture gives the scicula a particularly conspicuous bilateral symmetry, on account of which the animal at this stage recalls a bryozoan rather than a modern hydroid polyp.

The Theca. Before the scicula has matured, there forms, at the point illustrated in Pl. II., fig. 4, the beginning of a second tube, which is also provided with growth lines. The circular perforation by which it communicates with the cavity of the scicula has been observed in forty-one examples. This opening is not produced by absorption of the wall as shown by the slight irregularity of the scicular growth lines at the origin of the second tube (Pl. II., fig. 4). This tube does not develop into a general canal or similar part, but forms the first theca. Then from this one chamber of habitation there simply develops a second.

The first theca (Pl. II., figs. 4, 5) at once leans closely on the scicula, widens very rapidly, approaches toward the virgula, and in bending around the scicula passes it, so that the theca comes to lie on the back (dorsal) side[1] of the scicula, and eventually both increase at an equal rate towards the proximal end. The growth lines of the first theca like those of the scicula, although in a less degree, are also drawn along, so to speak, by the virgula. As soon as the theca, which clings closely to the virgula, has grown a little further than the scicula towards the proximal end, it again changes its direction, and bends outward and eventually upwards. Where it begins to grow upwards, it gives off from one to three spines in succession, which start with a slight emar-

[1] I have named that side the front which in figures 4 and 7, faces the observer.

gination of the wall, and appear to develop like the spines of mollusks. In one example (Pl. II., fig. 6), two approximate spines are joined by a thin skin. Therefore there are from four to six spines on the proximal end of this *Diplograptus*.

A second large hole opens on the first theca towards the front side (Pl. II., fig. 4). On the back side (Pl. II., fig. 5), the lines are disposed parallel with its margin; on the front, however, they converge. From this opening comes the second theca (Pl. II., fig. 7), on the right side in front of the scicula. Shortly after it has left the first theca, the turning of the hydrosoma must have taken place; *i. e.*, both thecæ now begin to grow in an opposite direction and thereby change the direction of the aperture towards the distal end. Further scicula growth probably ceases at this stage of development. The newly-formed theca fastens itself to the forward spine on the right side of the scicula.

The second theca hardly has left the first when it gives origin to the third, which also lies on the first, and is therefore situated on the left side. The pore uniting the third theca with the second is situated a little more proximally than that which joins the second with the first. The earliest budding of the third theca, therefore, occurs between the origin of the second and the turning of the hydrosoma. Its lower part fills the space in the bend of the first theca (Pl. II., fig. 8).

In my material occur many specimens having only the scicula, the first two thecæ, and the proximal portion of the third. If such an example were pressed flat without relief, and changed into pyrite, it would be recognized as a scicula having two buds with a common canal. The third theca increases only at the distal end. From it, the fourth theca takes its origin, and is situated in front of the scicula on the right side of the hydrosoma (Pl. II., fig. 8).

Even if the openings between the first and second and the second and third thecæ were not apparent, but only the origin of the first theca from the scicula and the fourth from the third were observed, the following law for the formation of the thecæ could be deduced: Each theca has its origin in the next on the

opposite side of the hydrosoma. The alternating of the thecæ, therefore, is not only governed by the greater space attainable, but by the age and origin of the thecæ as well. In certain respects this law is also true for the scicula which may be regarded, if desirable, as the primary theca.

The growth lines meet on the outer edge of the hydrosoma in such a way as to produce a zig-zag line (Pl. II., fig. 7). This is probably produced by the same cause as the marking of the lobes of the scicula. Analogous to these, also, are the well-known paired spines of the thecal apertures of certain diplograptids, which are likewise an expression of the bilateral symmetry of the thecæ.

The partition wall between two adjoining or opposite thecæ is naturally double, and exhibits a slight thickening on the proximal inner edge.

The angle between the median line of the hydrosoma and the double partitions of the thecæ is greater in the distal portion, (25°-30°) than in the proximal, where it is occasionally zero.

An examination of figures 8 and 9 shows that the scicula originally lies outside of the hydrosoma, except for the loose adherence of the thecæ, being united to it only at the termination of the first theca. Nevertheless the earliest thecæ are indented on the dorsal side and partly enclosing the scicula, so that it appears to lie in a depression of the outside of the hydrosoma. The thecæ extend more and more over the scicula until the central space is nearly transformed into a tube encircling the scicula, and when the fifth theca, *i. e.*, the third on the same side as the first, finally opens, the scicula then disappears into the hydrosoma (Pl. II., fig. 9). The place where the scicula comes in contact with the perforated wall of the hydrosoma lies beneath the boundary between the two parts of the scicula (Pl. II., fig. 9).

The Virgula. As the virgula has been observed to occur within, and protrude from, both ends of the hydrosoma, it has been naturally concluded that the virgula passed without interruption through the entire hydrosoma. This, however, is not the case (Pl. II., figs. 1-3). The origin of that portion of the virgula which lies in the left wall of the proximal part of the

scicula has been already described. This part like the scicula grows towards the proximal end. The distal portion of the virgula does not begin to develop until the scicula has been taken into the hydrosoma. It is likewise stouter the further it is removed from the point of the scicula. As it has its origin in the union of the longitudinal lines of the distal portion of the scicula, it appears very probable that the entire distal part of the scicula, also, first had its inception when the scicula is taken into the hydrosoma. Accordingly, the scicula, when it was yet free, would have been either open on the distal end or it had a very thin wall which disappeared later. The first shell-layer, therefore, was a small simple ring.

Here and there, quite irregularly, the virgula fastens itself to the above-mentioned swellings on the proximal ends of the thecal partitions (Pl. II., figs. 11-12). In figure 10, it is entirely free. In diagnoses of diplograptids, it is often mentioned that the virgula extends beyond the distal end. This need not be accidental in a species of this nature, since in forms where the virgula is not fastened to the diagonal swellings, it has a greater chance of being preserved, even if the periderm is broken away. If the virgula is regularly attached to every partition, it can only become protruding under very favorable circumstances. In this species, I did not see the virgula protruding.

A common canal as progenitor for all thecæ does not exist. The partition walls between the thecæ, moreover, join so closely on the center of the hydrosoma that the virgula hardly has sufficient space to straighten itself.

A longitudinal septum is not present.

In summing up the results of my investigations, the following points are shown :

1. The scicula consists of two parts, is basally open, and bilaterally symmetrical.

2. From the scicula there sprouts but *one* bud. This *Diplograptus* is therefore monoprionidian.

3. This bud does not develop into a canal, but into a theca.

4. Each theca comes forth from the next more proximally

situated theca of the opposite side, and not from a common canal.

5. The hydrozoma including the virgula has grown in two opposite directions.

6. The scicula is not imbedded between two branches grown together, but is free originally, and later is incorporated within the periderm.

7. The virgula is not double, and has two quite distinct phases of development.

8. To the virgula are occasionally attached the bases of the thecal partitions.

9. A common canal as progenitor of the thecæ does not exist.

10. A double longitudinal septum is not present.

It is not now my intention to assert that this organization is repeated in all the representatives of the family *Diplograptidæ*, for so little of their internal structure is yet known, they may have a collection of remotely related forms with thecæ arranged in two rows, but since this family is entirely or in the main a natural one, the deviation from the general plan of structure cannot be very great.

Eight days after I had announced the above before the geological section of the Student's Natural History Society, and after I had nearly finished writing it, I received from S. L. Tornquist a copy of his work "Observations on the structure of some *Diprionidæ*." Särtryck af Kongl. Fysiografiska Sälls Kapets Handlingar. Ny följd 1892-3, Bd. 4, Lund, 1893. Lund Univ. Årsskrift, tom XXIX.

The "connecting canal," which, according to Tornquist, unites the scicula with the "common cavity of the rhabdosoma," is that part of the first theca which grows downwards. The proximal end of *Climacograptus scalaris*, Lin., figs. 7–15, and 18-20, *C. internexus*, Tqt., fig. 25, *Diplograptus palmeus*, Barr., figs, 29, 33–35, and *Cephalograptus cometa*, Gein., figs. 39–41, show the identical structure which I have just described. The groove illustrated in figure 17 and mentioned on page 6 as "a narrow longitudinal groove as to the nature of which I am not

able as yet to offer any satisfactory explanation," can be, since it terminates before it reaches the point of the scicula, nothing else than that portion of the virgula which lies in the wall of the scicula.

Tornquist nowhere says that the described species are monoprionidian, but this can be clearly seen in the figures 39-41 of *Cephalograptus cometa*, Gein., and if those just cited are compared with my own, there can be no doubt that the species above mentioned are also monoprionidian.

It is particularly interesting to note that the presence of a longitudinal septum does not depend on the diprionidian character of the *Diplograptidæ* as generally accepted.

EXPLANATION OF PLATE.

The figures have been drawn about twice the size of the scale, with Zeiss and Abbe's drawing apparatus. The shading was obtained by still greater enlargement, and by various accessories to the microscope. The given scale does not apply to figure 10.

Fig. 1. Young scicula; dorsal side. × 37.

Figs. 2-3. Adult scicula; front view. The thecæ are removed. 37–1.

Fig. 4. Form and place of the first theca and the perforation from which the second will come; front view. × 37.

Fig. 5. The same; dorsal view. × 37.

Fig. 6. The first theca with three spines, two of which are united by a thin skin. × 37.

Fig. 7. Form and position of the second and third thecæ; front view. × 37.

Fig. 8. Form and position of the fourth theca and imbedded scicula. × 37.

Fig. 9. Incorporation of the scicula in the hydrosoma. × 37.

Fig. 10. Distal portion. The transparency partially made use of. The virgula is wholly free. × 13.

Figs. 11-12. Attachment of the proximal edges of the partitions to the virgula. × 37.

The material is in the collection of the Geological Institute at Upsala.

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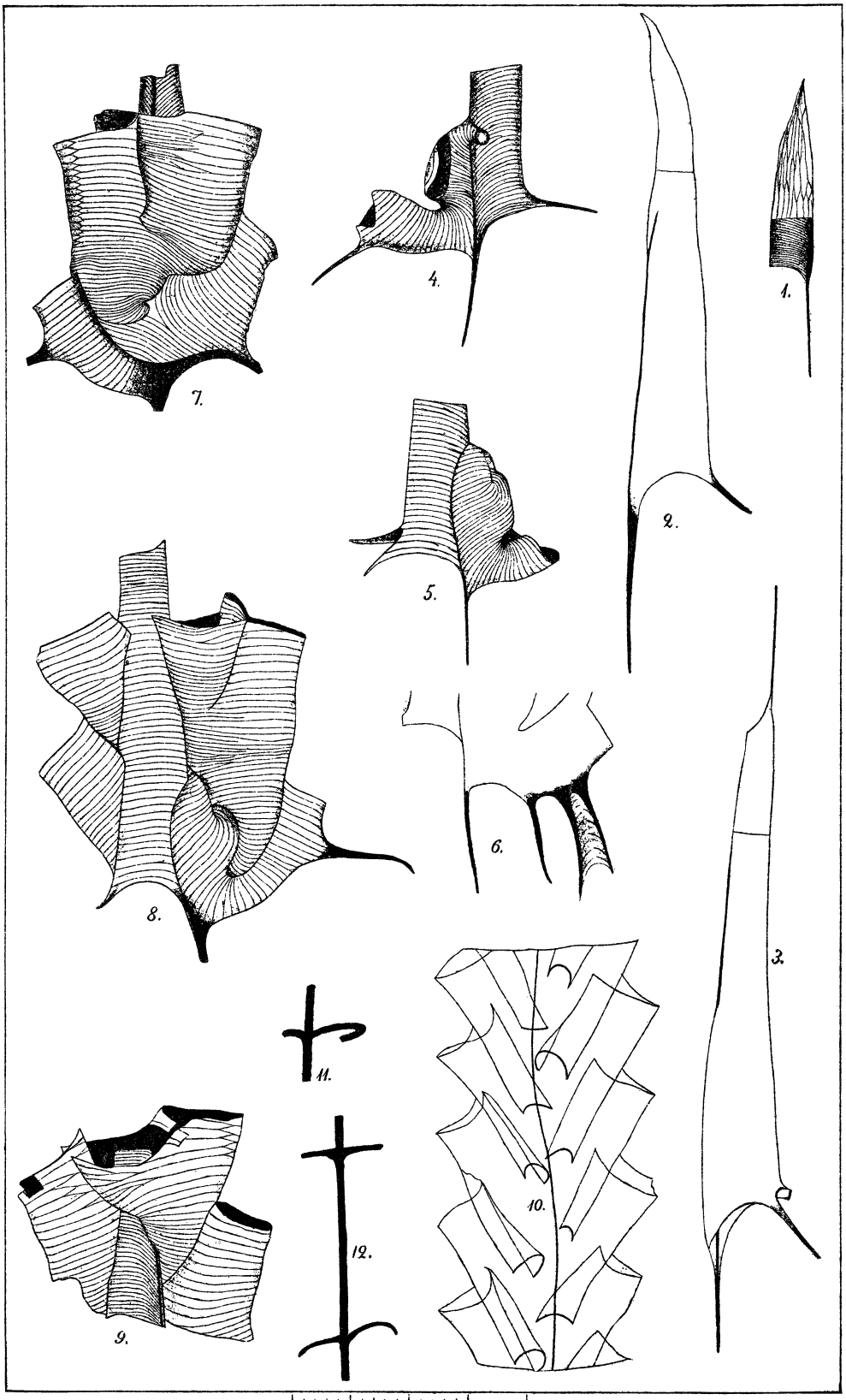
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